Addressing Cold Regions Issues in Pavement Engineering

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ERDC - CRREL

US Army Corps of Engineers®
Engineer Research and Development Center

Tri-Services Infrastructure Systems Conference

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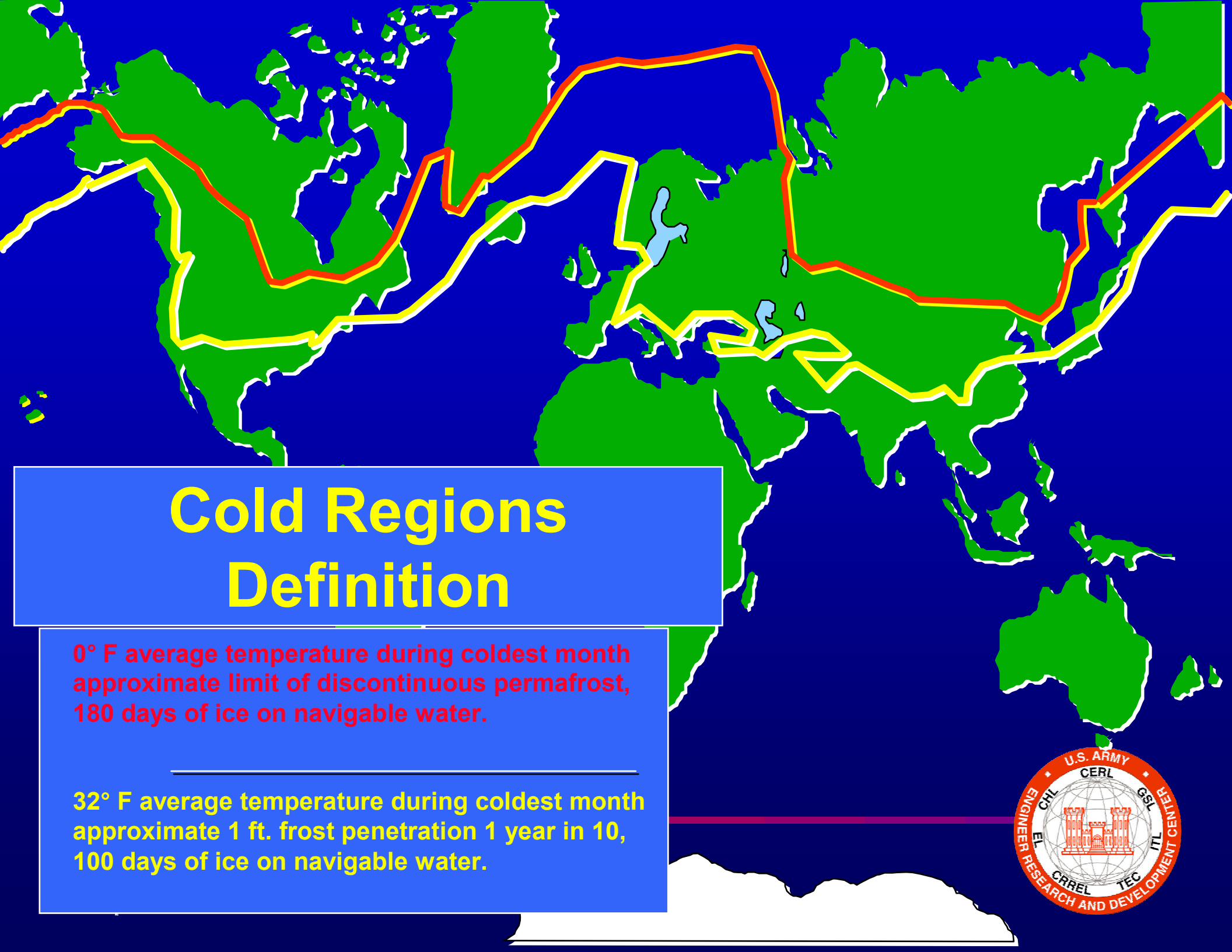
Cold Regions
Definition
0° F average temperature during coldest month
approximate limit of discontinuous permafrost,
180 days of ice on navigable water.
32° F average temperature during coldest month
approximate 1 ft. frost penetration 1 year in 10,
100 days of ice on navigable water.
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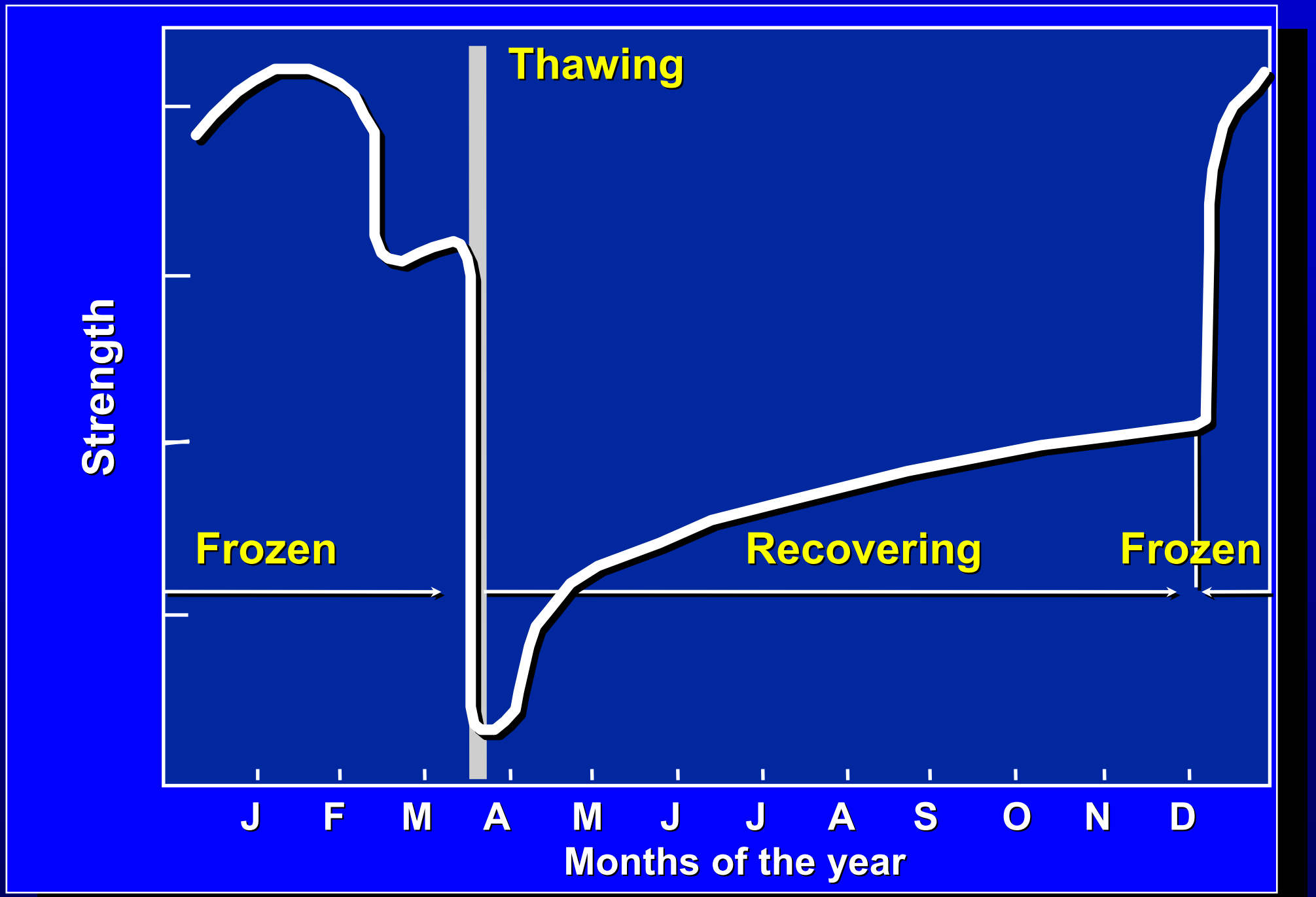
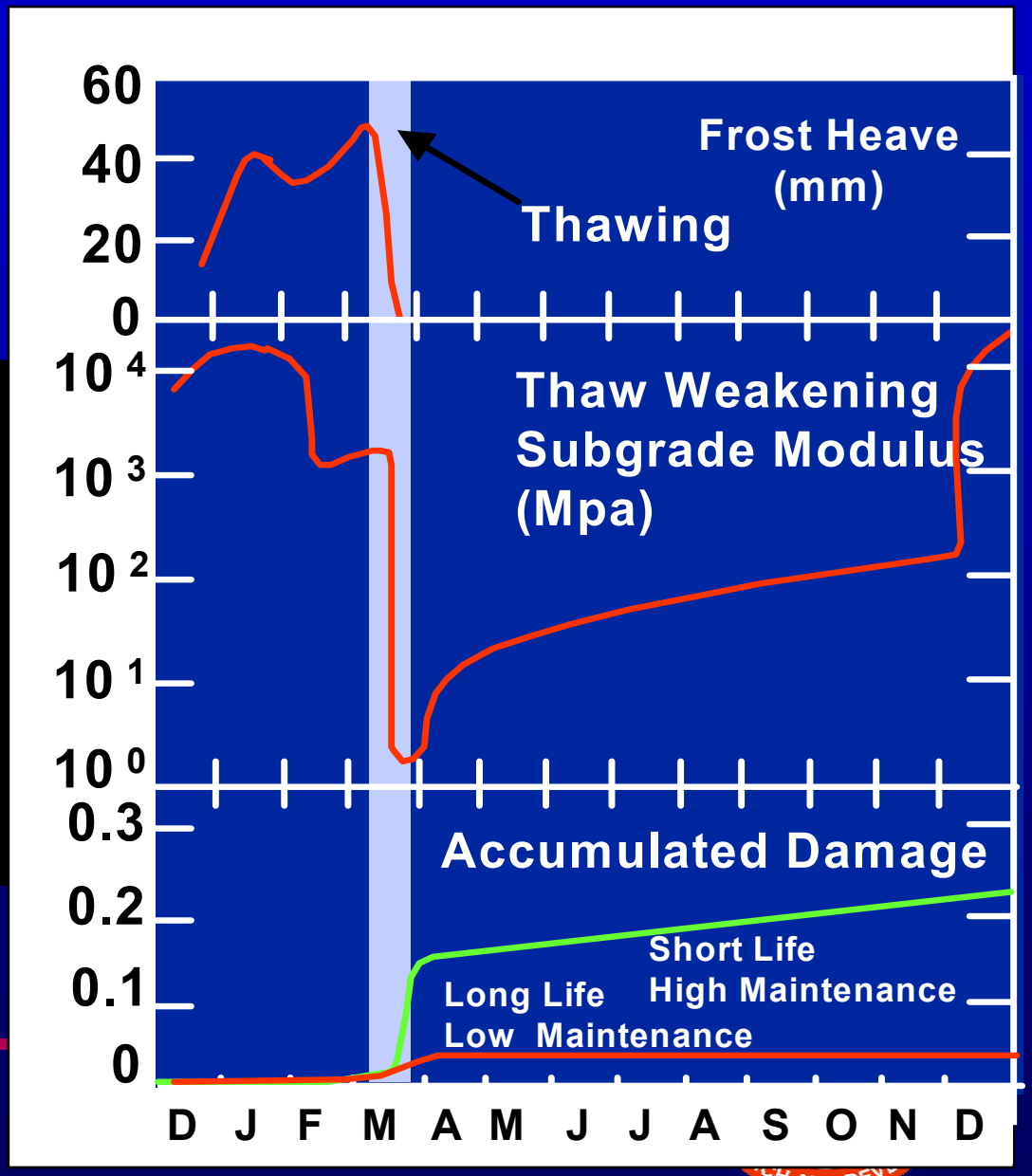
Seasonal Variations in Frost Areas



Problems

- Frost heave
- Thaw weakening
  90% damage
- Drainage
- Thermal cracking



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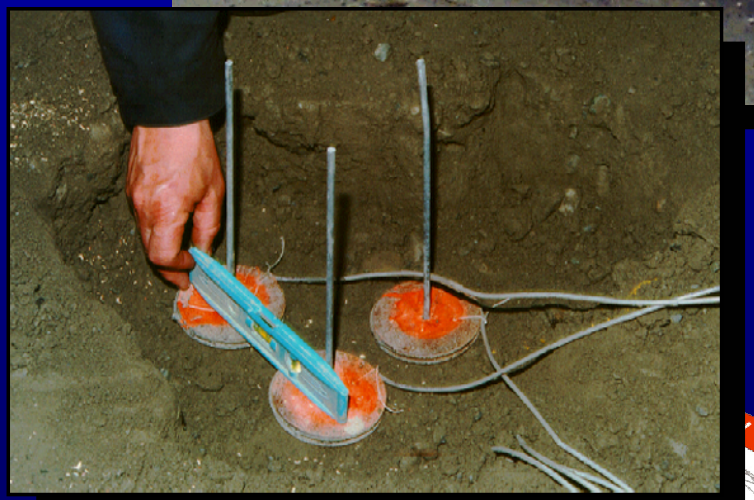
ERDC – CRREL:
Cold Regions Research and Engineering Laboratory
Hanover, NH

ERDC-CRREL Research Areas

- Subgrade mechanistic analysis
- Antifreeze concrete
- Geosynthetics
- Frost heave / thaw weakening
- Drainage
- Mechanistic pavement design
- Soil stabilization
- Recycled materials in pavements
- Waste materials in pavements
- Material characterization
- Pavement evaluation criteria
- Non-destructive pavement testing
- Instrumentation
- Anti-icing, snow & ice control



*Semi-prepared airfield mats

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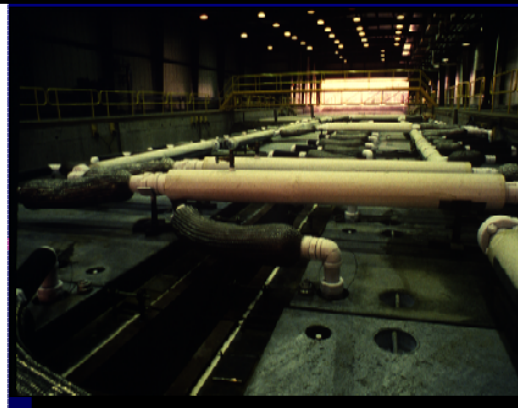
Testing Facilities

- Frost Effects Research Facility (FERF)
- Materials laboratory
- Cold room complex



Frost Effects Research Facility (FERF)

HVS in a Moisture-Temperature Controlled Environment

+

= Unique

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Pavement Testing Equipment

Falling and Heavy Weight Deflectometer

Laboratory testing equipment

- Frost heave test
- Material characterization

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Recent Research:

Antifreeze Concrete

- An available, demonstrated product
- Accepted by ASTM
- Capability to Mix, Place, and Cure concrete without the need for heat down to 23°F
- Uses commercially available admixtures to depress freezing point of mix water and promote strength gain
- Placed directly on frozen substrate

www.crrel.usace.army.mil/concrete/

Air temp. = 14°F (Hi 28°F/Lo 0°F)
Concrete temp. = 50°F

West Lebanon, NH (December 2002)

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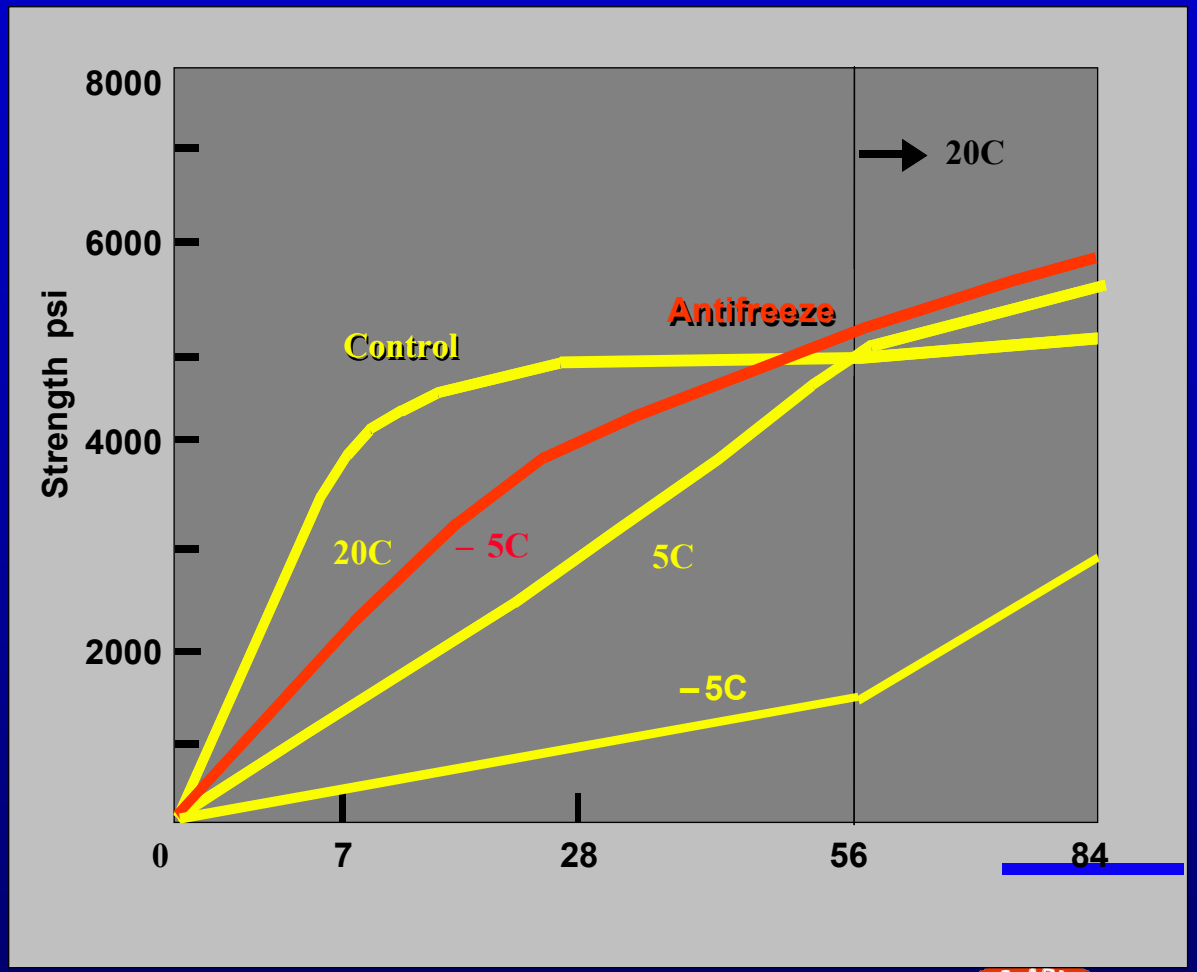
Antifreeze Admixtures

- Lower freezing point of mix water
- Accelerates strength at low temperature



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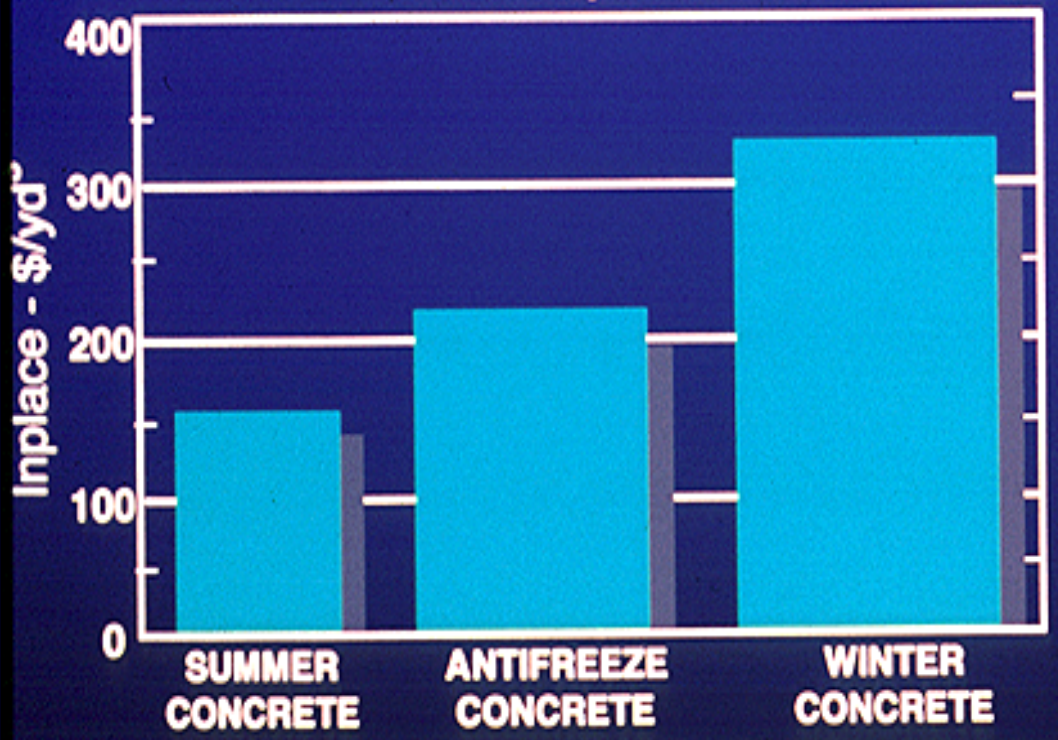
Low Temperature Admixtures Save Money and Time

Cost Comparison



Construction Season (-5°C Admixture)

Extended up to 60 days
Extended up to 120 days
Year-round

Current Research Projects

- Pavement Subgrade Performance for New Mechanistic Design
  19 states + FHWA
- Geogrid Base Course Reinforcement to Extend Pavement Life
  9 states + FHWA

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Current Research:

Pavement Subgrade Performance Study

National Pooled Fund Study

SPR2-(208)

- Pennsylvania
- California
- Texas
- New Hampshire
- Connecticut
- New York
- Kansas
- Florida
- Minnesota
- Indiana
- Alaska
- Alabama
- Georgia
- Oregon
- Ohio
- Montana
- Nebraska
- Idaho
- North Dakota

- Texas Transportation Research Institute
- Cornell University
- Kansas State University
- Louisiana State University
- University of Maryland
- University of New Hampshire

U.S. Department of Transportation
Federal Highway Administration

Principal Investigator
Edel Cortez

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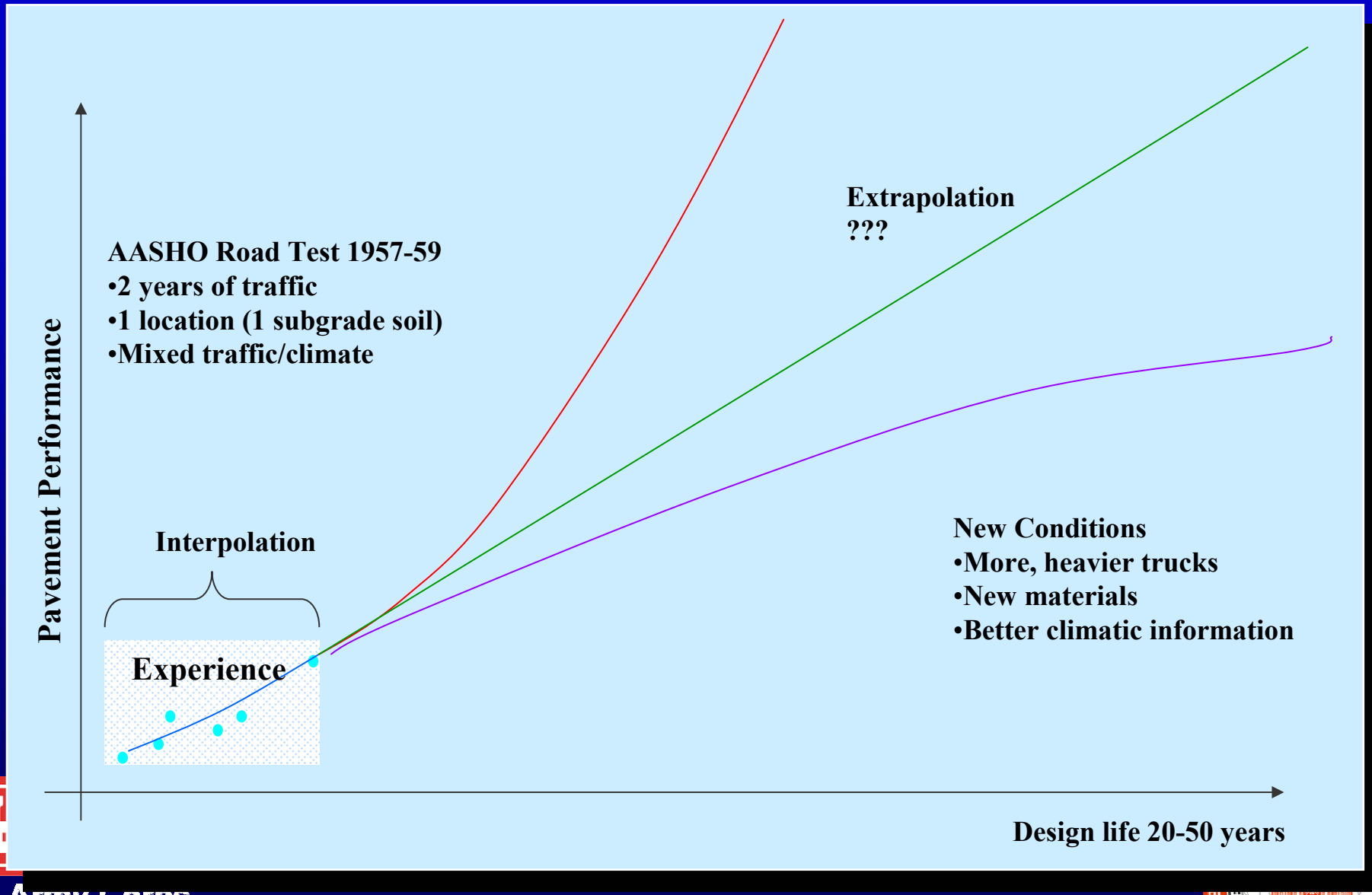
Cold Regions Research and Engineering

The Problem:

Current Empirical Design Method



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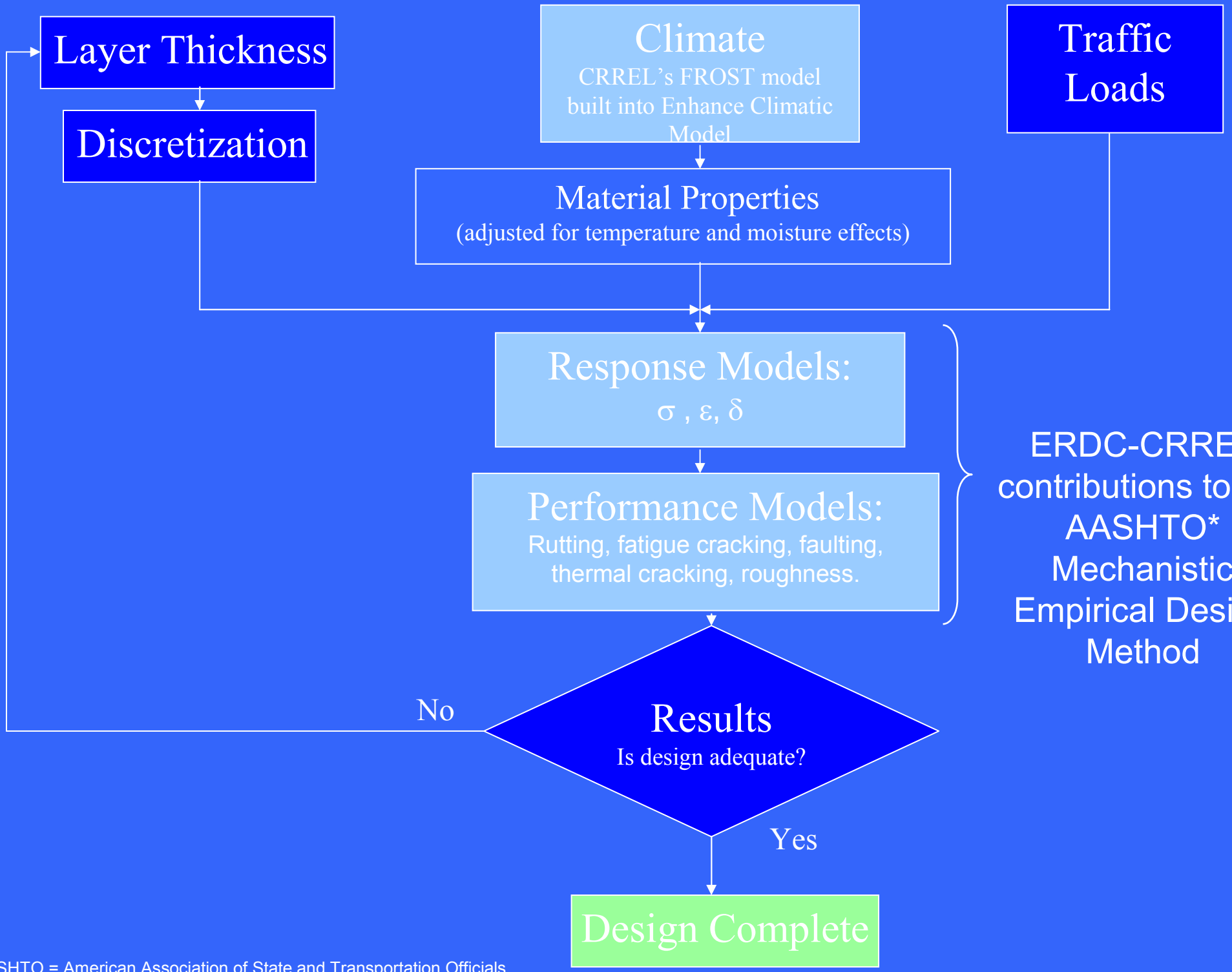
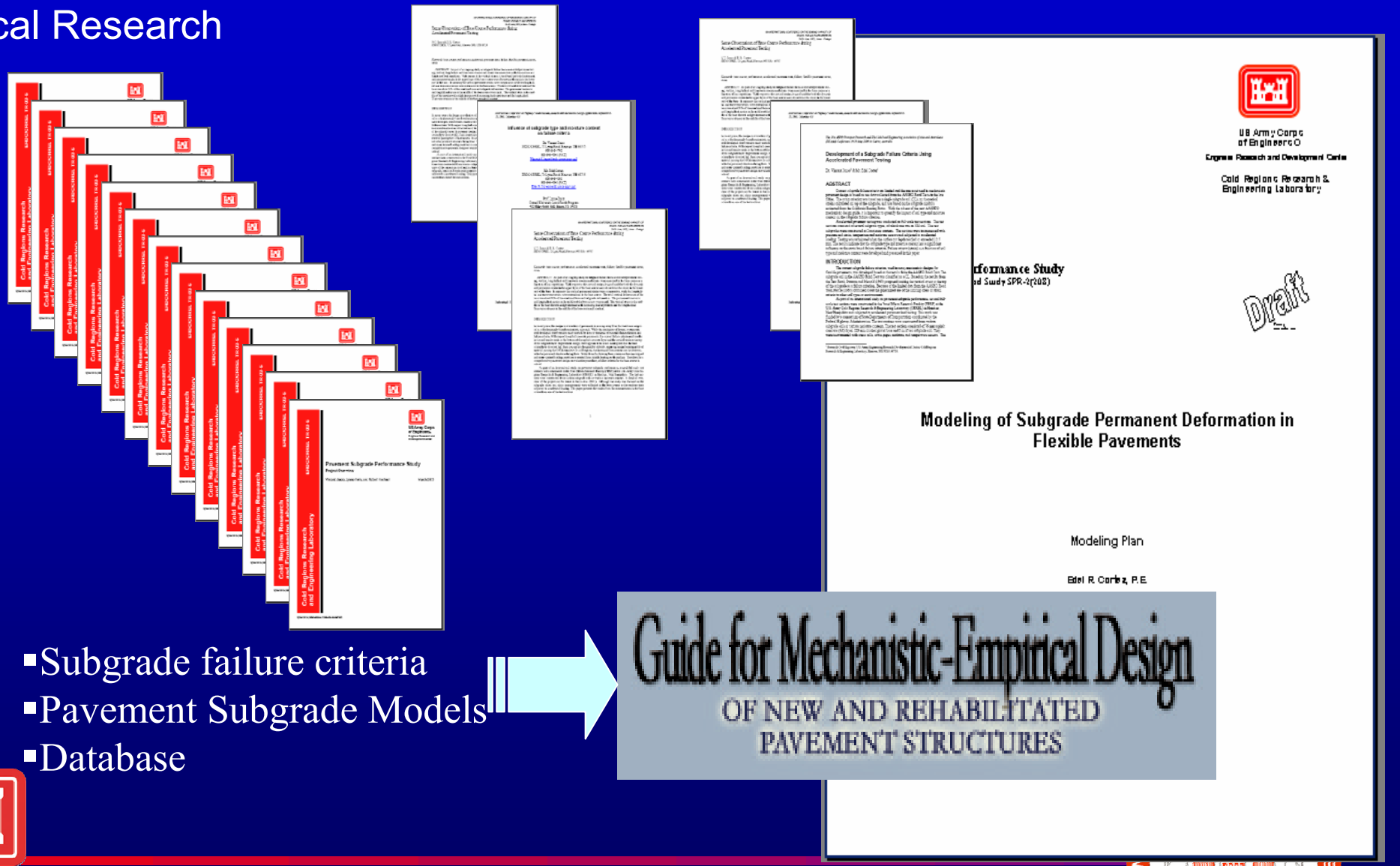
AASHTO M-E Framework



* AASHTO = American Association of State and Transportation Officials

Experimental Research
+
Analytical Research

Deliverable Products



- Subgrade failure criteria
- Pavement Subgrade Models
- Database

Guide for Mechanistic-Empirical Design
OF NEW AND REHABILITATED PAVEMENT STRUCTURES

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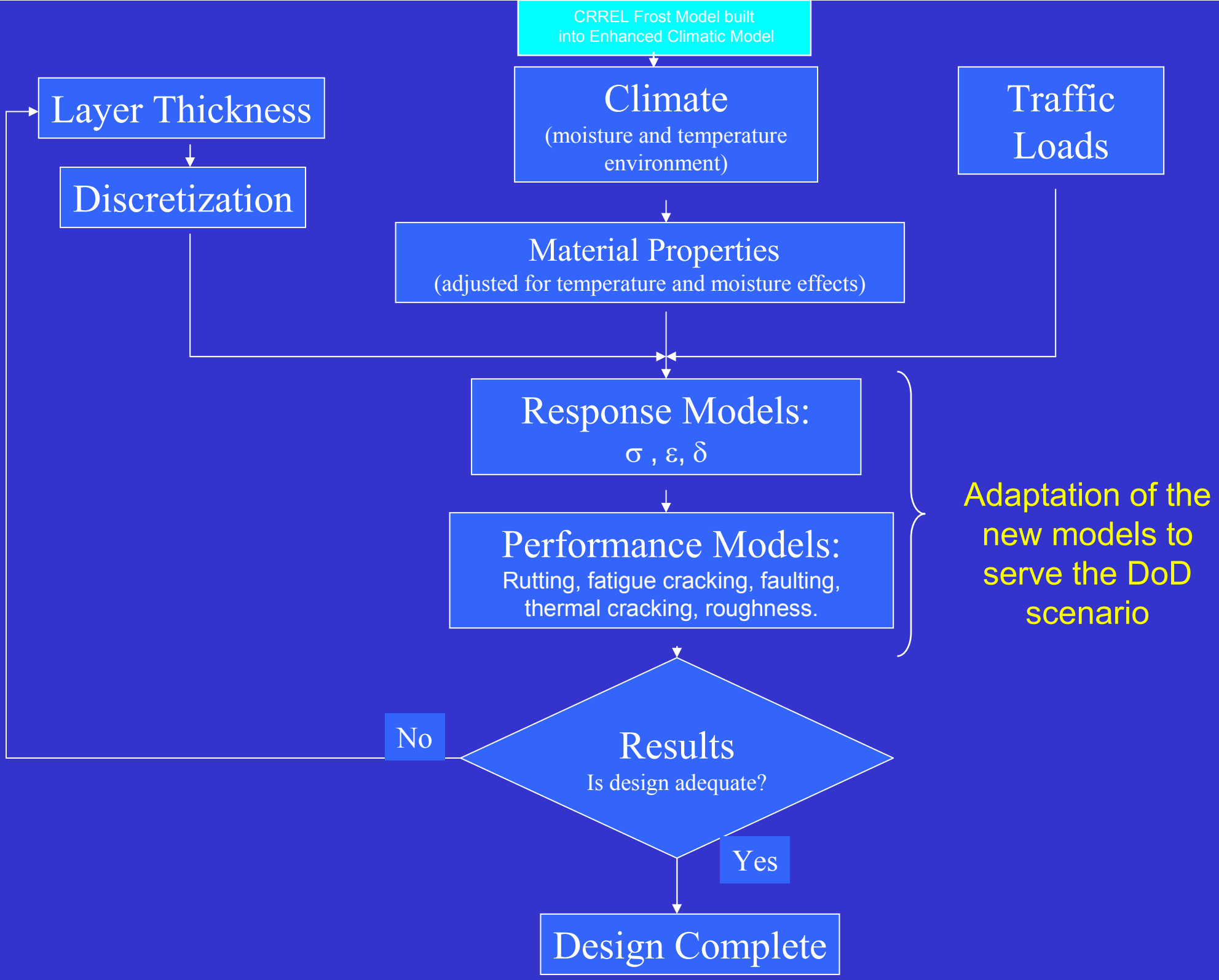
Project Cost: $2.3 million


CRREL Frost Model built into Enhanced Climatic Model
Layer Thickness
Climate
(moisture and temperature environment)
Traffic Loads
Discretization
Material Properties
(adjusted for temperature and moisture effects)
Response Models:
σ , ε, δ
Performance Models:
Rutting, fatigue cracking, faulting, thermal cracking, roughness.
Adaptation of the new models to serve the DoD scenario
Results
Is design adequate?
No
Yes
Design Complete

Conclusions

- Seasonal effects (freeze-thaw, cold temperatures, moisture changes, etc) may have significant impacts on pavement life and performance.
- CRREL is a component of the ERDC.
- ERDC-CRREL is a laboratory specialized in cold regions issues that are a part of larger research problems in pavements (and in other areas).
- Teaming across ERDC laboratories (i.e., GSL-CRREL) optimizes R&D productivity.

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